

## **Indoor Air Quality and the Function of Fresh Air Supplies and Exhaust Vents in Schools, Part I**

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*This article is the first part of a series that explain how a building's indoor air quality can be affected by ventilation systems. This first installment explains the function of univents and exhaust vents.*

Of the multitude of conditions that can effect indoor air quality in a school, the mechanical ventilation systems can play a significant role. Over the course of numerous building evaluations done by the Massachusetts Department of Public Health, Bureau of Environmental Health Assessment (BEHA), numerous public schools evaluated have had indoor air quality that was adversely effected by the mechanical ventilation systems. Some of these problems are related to operation, some are related to misunderstanding the purpose of mechanical ventilation equipment. Since the unit ventilator (univent) is the most commonly found equipment that is used to provide fresh air and temperature control in schools, the following will explain the function of this equipment in concert with a mechanical exhaust vent system in maintaining air quality.

### **The Univent**

The univent is an air handling unit that provides fresh air for an individual room. Univents are preferred for use in rooms that require the introduction of large amounts of fresh air into a room while providing temperature control. The internal parts of the univent are illustrated in Figure 1.

The univent is usually positioned on the exterior wall of a classroom, usually underneath the window system. The univent draws fresh air from outdoors through a vent on the exterior wall. The univent also draws air from the classroom (return air). Air through each of these vents is controlled by louvers in the base of the univent. The percentage of fresh air is controlled by the angle that these louvers are set.

Fresh air and return air travel through a filter. The air is heated (or cooled) by the heating coil and ejected through the air diffuser by the univent fan.. Some univents are equipment to provide air-conditioning during summer months. Located underneath the cooling coil will be a drip pan to drain condensation. Univents are usually controlled through a thermostat located in the classroom. Centralized control through a pneumatic or computerized system can also be employed.

### **The Exhaust Ventilation System and the Creation of Airflow**

Located on the interior wall in a exhaust vent that is connected by ductwork to a rooftop ventilation fan. Airflow into the exhaust vent system is usually controlled by adjustable louvers or a flue that is opened by a draw chain-pulley system. Airflow in the flue system is controlled by setting the flue at a desired angle by setting the draw chain in a locking mechanism. The exhaust

system ductwork can be connected to either a open sheltered roof vent or an exhaust vent motor. Rooftop exhaust motor usually has a motor connected by a belt to a fan.

A functioning univent with an activated exhaust ventilation system will create airflow in the classroom. Airflow from and into vents is measured in cubic feet per minute (cfm). In general, the cfm output from the univent and the cfm drawn by the exhaust vent should roughly be equal (or in balance). Figure 2 denotes air flow created by this ventilation system.

As the univent and exhaust vent function, airflow to distribute fresh air and heat/air condition air is created in each room. The exhaust ventilation serves to remove carbon dioxide, dust, water vapor and other pollutants from the classroom.

*Part 2 of this series will describe how the ventilation system can malfunction through lack of maintenance.*

## **Indoor Air Quality and the Function of Fresh Air Supplies and Exhaust Vents in Schools, Part II**

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*This article is the second part of a series that explain how a building's indoor air quality can be affected by ventilation systems. This second installment denotes conditions that can be seen within or around a classroom univent that are signs of a lack of attention to maintenance of this equipment.*

In the previous installment of this series, the function of univents and exhaust ventilation was described. Under optimum conditions, the univent and exhaust ventilation create airflow in a classroom. By functioning properly, a univent providing fresh air and the exhaust vent removing stale air and pollutants can both maintain comfort within a classroom. If these systems are not functioning as designed, environmental pollutants can build up and cause symptoms.

The cause of degradation of univent function can be attributed to lack of maintenance in the room or of the univent itself. The following are signs that the univent system is not operating as designed. Each of these conditions were noted by Bureau of Environmental Health Assessment personnel during indoor air quality assessments in Massachusetts schools.

- Accumulation of dust on the return intake vent.
- Heavy deposits of dust on the univent filter. This can be a sign that the univent filter is not changed on a routine basis.
- Accumulation of debris inside the univent above the fan units. Accumulation of crayons, paper, food, and other debris can be a sign that univents are not routinely cleaned.

- Storage of books, boxes, paper or other materials on top of the univent. Storage of materials which block airflow prevents the univent from functioning.
- Production of air from the univent at or near outdoor air temperature. This can be a sign that the fresh air damper may be frozen open, allowing outdoor air to be preferentially drawn into the univent. This condition may result in pipes bursting due to heating coils freezing.
- Production of excessive heated air from the univent. This can be a sign the fresh air damper is closed, preventing fresh air from mixing and tempering return air temperature.
- Controls within the univent fail to activate univent motors. This can indicate that univent motors are disabled or univent controls are disconnected..
- The room temperature does not match temperature setting on the thermostat. This can indicate that thermostats are disabled and are not controlling the activation of the classroom univent.
- Missing vanes or substitute covers over the univent air diffuser. Failing to fix vanes in univent air diffusers can allow for materials to fall into the univent and damage the motors. In some case, damaged diffusers have been seen to be replaced with plexiglass or sheet metal drilled with small holes. By replacing damaged air diffusers with substitutes that do not allow airflow equal to the original diffusers degrade the function of univents.
- Leaves and other plant debris in the space above the filter rack can indicate filters were not have installed. The presence of plant debris above the filter rack also indicates that the interior of univents were not routinely cleaned.
- Signs of animal wastes within the univent casing can be a sign of nesting of pests.

- Upon activating heat only univents, a stale or mold odor is produced from the machine. If the univent provides only heat, this can be a sign of rain water penetration into the unit through outside brickwork or window systems. Water stains in the base of the univent casing can be a sign of water pooling and potential mold growth medium.
- If the univent is also provides cooling during the summer months and produces a mold odor, this can indicate inadequate draining of condensate from cooling coils or chilled water supply pipes. Failure to pitch the drain pan in a univent to drain condensate can lead to pooling water and subsequent mold growth. Uninsulated chilled water pipes outside the cooling coil chamber can result in dripping, undrained condensate and subsequent mold growth in wetted materials. Green colored corrosion on copper pipes or rust on steel electric components can be a sign of condensation in univents.
- Frayed or damaged fiberglass insulation within the heating coil chamber. Degrading fiberglass can indicate water damage. Degraded fiberglass insulation can also be aerosolized by univent fans.
- Activated univent motors without spinning fans can be a sign of broken or slipping fan belts.

Each of these conditions can lead to the degradation of univent function, which can lead to a decrease in the provision of filtered fresh air into classrooms. Each of these conditions should be examined and repaired or remediated where found.

*Part 3 of this series will describe how the exhaust ventilation system can malfunction through misunderstanding of function by building occupants or through lack of maintenance.*

Cory Holmes and Suzan Donahue contributed to this article.

## **Indoor Air Quality and the Function of Fresh Air Supplies and Exhaust Vents in Schools, Part III**

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*This series of articles explain how a building's indoor air quality can be affected by ventilation systems. This third and final installment explains how malfunctioning exhaust ventilation systems can adversely effect indoor air quality.*

(Originally published in PH Professional November 2000)

As noted in previous articles in this series, ventilation systems consist of two distinct sections, fresh air supply and exhaust vents. Problems with exhaust vents can play a roll in either creating or exacerbating conditions that can result in increased complaints of odor, discomfort or other related conditions that are associated with poor indoor air quality. Where the purpose of supply vents is to provide fresh tempered air into an interior space, exhaust ventilation is designed to remove stale air. As air is removed, indoor air pollutants that are within any building are directed outdoors. In school buildings, exhaust ventilation systems can be divided into two categories: general ventilation that works in concert with the fresh air supplies or exhaust vents that are dedicated to a specific activity or purpose. The following conditions should be considered as they can have a negative impact on indoor air quality.

### **General Exhaust Ventilation**

-Examine exhaust vents for blockage by classroom materials. In almost every investigation by BEHA staff, exhaust vents blocked by filing cabinets, boxes, book shelves, wall posters, furniture and other common classroom items have been found in

classrooms across Massachusetts and contributed to air measurements that exceed air quality/comfort guidelines established by the MDPH. Blockages of these vents prevent this equipment from exhausting air from classrooms. In numerous cases, items have been placed which block exhaust vents because building occupants do not know what purpose these vents serve. As a rule, exhaust vents need an unobstructed path to the interior of the room in order to maximize efficiency.

- Airflow into exhaust vents in older schools (pre-late 1960's in general) may be controlled using a louver system located in a hearth-like structure on the interior wall of the classroom. Airflow into these vents is controlled by the angle of the louver within, which is set in place by a chain and pulley system. If the chain that fixes the louver is seen hanging at the rear of the hearth, this usually indicates that the exhaust vent louver is closed, resulting in no exhaust ventilation.

- In newer buildings, moveable vanes on the exhaust vent grill are used to control airflow into this vent. If these vanes are frozen closed, airflow is restricted.

- If exhaust vents are purposely blocked with paper or are found to be backdrafting cold air, this can indicate that the motors controlling the airflow for the exhaust vent are either broken, missing fan belts or are wired inappropriately.

- The activation/deactivation of general exhaust vents in classrooms are frequently controlled by thermostats in equipment. Once a thermostat detects a preset temperature,



the exhaust ventilation system is activated. Exhaust ventilation should operate at all times that the fresh air supply is in operation. The fresh air supply system should be in operation when an area is occupied.

-Some older buildings use a non-mechanical exhaust ventilation system that relies on rising heated air to create exhaust ventilation. These systems are called natural ventilation systems. Airflow into these vents is usually controlled by a louvered, chain and pulley system previously noted. Frequently, these systems terminate in roof structures that resemble chimneys. These particular systems are highly vulnerable to bird roosting. Bird droppings can be a source of several diseases. If bird roosting is suspected or wastes are found in the floor of vents, removal of wastes and disinfection with an appropriate antimicrobial by trained professionals should be done.

### **Typical IAQ Problems Related to Exhaust Ventilation**

Several areas in schools or other buildings will have areas with specially designed exhaust ventilation systems that are designed to remove noxious odors or chemicals from within occupied spaces. Exhaust ventilation should be designed in these areas to place the room or a specific piece of equipment under negative pressure. If the area or equipment is placed under negative pressure by the exhaust ventilation system, materials or odors being generated in these areas should have no impact on adjacent space. The following conditions are commonly encountered observations indicating malfunction, poor performance or operation of these forms of exhaust ventilation.

-Lingering odors or moisture in restrooms can indicate inadequate or deactivated exhaust ventilation. Restrooms typically have exhaust vents without fresh air supplies to prevent odors and water vapor from penetrating into adjacent hallways or rooms. If odors, mold growth or unusual amounts of condensation are noted in rest rooms, these all can be signs of a malfunctioning or inadequate mechanical exhaust vent system. The lingering odor of deodorizers in restrooms may also indicate poor exhaust ventilation. Deodorizers do not remove odors but rather are used to mask unpleasant odors. If the exhaust system as adequately functioning, heavy deodorizer use or lingering odors would be rapidly eliminated from the restroom. Frequently, the restroom light switch activates exhaust vents. Restroom exhaust ventilation should operate during the hours of occupancy of a building.

-If cooking odors are noted beyond the kitchen and cafeteria, this can indicate malfunctioning stove exhaust vents.

-Wood dust odors in hallways adjacent to carpentry shops can indicate poorly operating or non-existent exhaust ventilation or wood dust collection equipment in shops. Please note it is recommended that a wood dust collection system have an exhaust vent to the outdoors. In a number of MDPH evaluations, wood dust collectors located indoors have been found lacking these vents. While filters in this equipment remove visible particles of wood dust, respirable wood dust particulates can be aerosolized into the interior of the wood shop. Respirable wood dust particles can be irritating to the eyes, nose and throat.

-In buildings with vocational education programs, the detection of vehicle exhaust in the building can indicate poor exhaust ventilation systems in automobile shops. Exhaust ventilation in these areas is particularly important due to the production of carbon monoxide from gasoline powered engines.

-Art rooms with heavy deposition of fine clay dust on flat surfaces can indicate inadequate ventilation for the pottery kiln. Local exhaust ventilation is important for such equipment because carbon monoxide, sulfur dioxide and lead fume may be emitted from the pottery kiln during use. These materials must be exhausted from the building to prevent exposure.

-Odors detected in hallways or classrooms immediately adjacent to science classrooms, science program equipment/chemical storage areas, custodial closets, autobody shops, cosmetology shops, metal shops, art rooms, photography dark rooms, print shops, swimming pools, stage areas or areas of a building that are under renovation can indicate poor exhaust ventilation in areas that may use chemicals or products containing odorous materials. In each of these cases, poor exhaust ventilation has been noted to play a role in failing to remove noxious materials resulting in building occupant exposure.

Another concern can be the location of where exhausted air exits a building. In a number of cases, exhaust vents have been found in close proximity to mechanical fresh air intakes. The location of exhaust vents in these areas can result in materials exhausted by the mechanical ventilation system being reintroduced into the building through the fresh

air supply system. The best practice is to locate special purpose exhaust vents at the greatest practicable distance from fresh air intakes. If not possible, the BOCA Code requires that vents emitting hazardous materials be at a minimum 10 feet distance on the horizontal plane or 2 feet above fresh air intakes (BOCA, 1993).

In each of these instances, a properly designed and operating exhaust ventilation system will remove environmental pollutants from the interior of a building and help reduce symptoms that are attributed to poor indoor air quality. As part of any indoor air quality investigation, an examination of exhaust ventilation may provide one piece of the puzzle that contributes to complaints of poor indoor air quality in a building.

*Cory Holmes, Suzan Donahue and Suzanne Condon of the MDPH Bureau of Environmental Health Assessment all contributed to this article.*

#### **Reference**

BOCA. , 1993. The BOCA National Mechanical Code/1993. 8<sup>th</sup> ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL. Section M-308.1.1.

## **HVAC and IAQ In Schools**

**Charles W Cochrane  
Cochrane Ventilation Inc.**

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## **Ventilation 101**

**Common types of systems  
found in New England**

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## **HVAC Designs**

⌘ Unit Ventilators

⌘ Forced hot air

⌘ HVAC

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## HVAC

### ⌘ Pro

- ☒ Most Versatile for ventilation and Thermal comfort.

### ⌘ Con

- ☒ Most costly of systems
- ☒ Little need for air conditioning.
- ☒ Most complex system

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## Forced Hot Air

### ⌘ Pro

- ☒ Provides for better air distribution
- ☒ less maintenance than unit ventilators
- ☒ Less noise

### ⌘ Con

- ☒ Higher front end cost
- ☒ Less Zone Control
- ☒ More technical controls

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## Unit Ventilators

### ⌘ Pro

- ☒ Inexpensive to install
- ☒ Simple to maintain
- ☒ Local Control

### ⌘ Con

- ☒ Higher maintenance cost
- ☒ susceptible to faculty interference

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## Reality

- ⌘ Unit ventilators in the class rooms
- ⌘ HVAC in the administrative and faculty areas

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## Problems

- ⌘ Cool space within a warm building shell.
- ⌘ Two types of systems
- ⌘ HVAC complexity



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## Common Issues

- ⌘ True preventative maintenance does not exist.
  - (build it and forget it)
- ⌘ Lack of training for maintenance staff.
- ⌘ Lack of training of faculty.
- ⌘ Lack of IAQ awareness.

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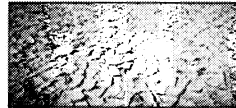
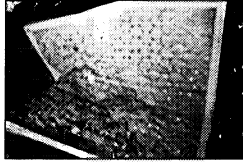
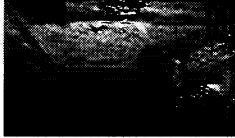
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## HVAC System Management

- ⌘ Filters
- ⌘ Drain Pans
- ⌘ Down Stream
- ⌘ Testing of liner



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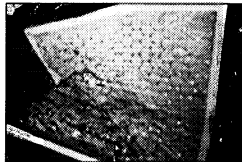
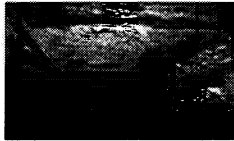
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## HVAC System Management

- ⌘ Filters
- ⌘ Drain Pans
- ⌘ Down Stream
- ⌘ Testing of liner



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## How do we achieve sustained PM

- ⌘ Develop a long term plan.
- ⌘ Establish a minimum Defensible standard for the School / Community.
- ⌘ Get school and community support

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## Getting Support

⌘ Being proactive after an avoidable loss.

⌘ Seek credible sources to build the program and your case.

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## Emerging Standards of Care



American Industrial Hygiene Association



American Conference of Governmental Industrial Hygienists



National Air Duct Cleaners Association

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## System Cleaning



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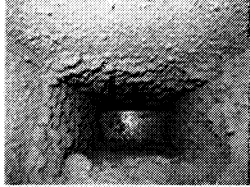
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## Reality of Dirty Ducts

⌘ No established cleaning frequency.

⌘ Clean equipment regularly.

⌘ Clean ductwork only after inspection demonstrates the need.



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## Guides and Standards

⌘ EPA

⌘ "Should You Have Your Air Ducts Cleaned?"

⌘ National Fire Protection Association (NFPA)

⌘ Standard 90-A

⌘ National Air Duct Cleaners Association (NADCA)

⌘ ACR 2002 Standard for Ventilation system assessment and cleaning

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## Ventilation Remediation Trends

⌘ Remote Imaging

⌘ Investigations

⌘ Verification



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## Microbial Remediation Strategies for HVAC systems




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## Leviticus

Chapter 14, Verses 33-47

⌘ "On the seventh day the priest shall return to inspect the house. If the mildew has spread on the walls, he is to order that the contaminated stones be torn out and thrown into an unclean place outside of town."




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## Biological contamination

⌘ "The presence of (a) biologically derived aerosols, gases and vapors of a kind and concentration likely to cause disease or predispose persons to adverse health effects, (b) inappropriate concentrations of outdoor bioaerosol, especially in buildings designed to prevent their entry, or (C) indoor biological growth and remnants of growth that may become airborne and to which people may be exposed"

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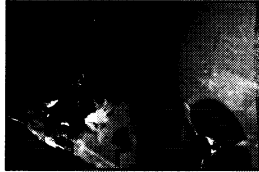
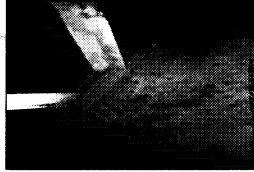
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## Moisture in HVAC Components

- %Air Intakes
- %Condensate Pans
- %Fan Housing
- %Humidifier
- %Condensate Drain



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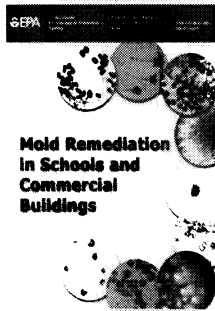
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## EPA



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## Other Resources



- % New York City Guidelines for Microbial Assessment and Remediation.

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## Treating / Sanitizing

⌘ What are Biocides

⌘ Who regulates  
Biocides

⌘ When should they be  
used?



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## Questions and Answers

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